Peiwei Li
INF2178
Shion Guha
05/04/24

1. Introduction

The term "dementia" echoes through the corridors of contemporary medicine, implying not only a single disease, but a myriad of neurological disorders characterized by declines in memory, cognitive ability and other life-impacting cognitive functions. Alzheimer's disease is one of the most prevalent and troubling diseases affecting the elderly population; it often leads to a gradual loss of identity and independence. Alzheimer's disease itself accounts for 60-80 percent of dementia cases, making understanding dementia and early detection of symptoms critical to public health. As a non-invasive diagnostic technique, MRI is critical to improving our understanding of brain anatomy and function. It can show small changes in brain volume and structure that often precede the clinical manifestations of dementia. As a result, MRI scans have become a useful tool for tracking disease progression and making early diagnoses.

The MRI scans is about a long-term study to track changes in the brains of people with and without dementia. With the help of this data, it will be possible to understand how aging affects brain morphology and how dementia develops. We are trying to determine how a person's brain volume changes over time in order to predict the onset of dementia using mixed effects ANOVA.

This leads us to the following research questions:
How do MRI measurements evolve in individuals with dementia compared to those without? Among the suite of MRI-derived metrics, which ones hold the strongest correlation with the stages of dementia? Is it possible to predict the onset of dementia with these measurable changes in brain volume before clinical symptoms manifest?

Here are several initial assumptions to guide the interpretation of the tests:
The sample data reflected the different stages of dementia, that MRI measurements (e.g., brain volume) were reliable and consistent across participants. And that changes in MRI results were primarily caused by the progression of dementia. In addition, we believe that the statistical techniques we chose were appropriate for our data and were successful in identifying any patterns associated with dementia. These theories are crucial to our understanding of how to interpret our results, and we will test the validity of these theories through our analysis.

2. Results

Our exploratory analysis revealed distinctive trends in estimated total intracranial volume (eTIV) and normalized whole brain volume (nWBV) among groups, hinting at possible markers for dementia. Line graphs (Fig. 1) show changes in nWBV for those with and without dementia, including those transitioning between these states. A notable downward trend suggests a reduction in nWBV over time among individuals diagnosed with dementia or those whose condition has progressed.

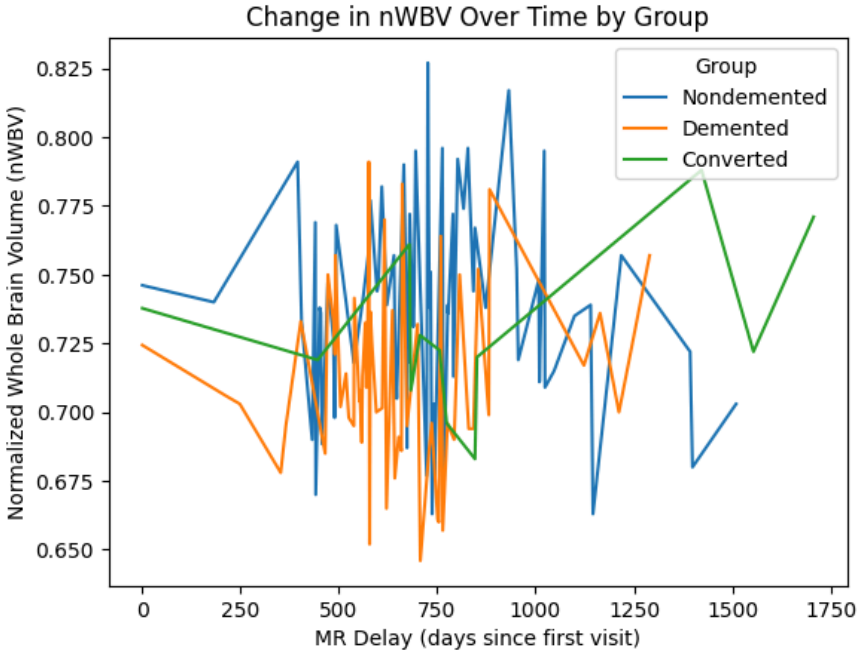

Figure. 1

In our mixed-effects linear regression analysis, a significant negative relationship between nWBV and the clinical dementia rating (CDR) was observed, with a coefficient of -3.837 ($p<0.001$), indicating that decreases in nWBV could be associated with advanced stages of dementia. In contrast, eTIV did not exhibit a significant link with dementia severity (Figures 2 and 3). This points to nWBV as a promising indicator for assessing the progression of dementia.

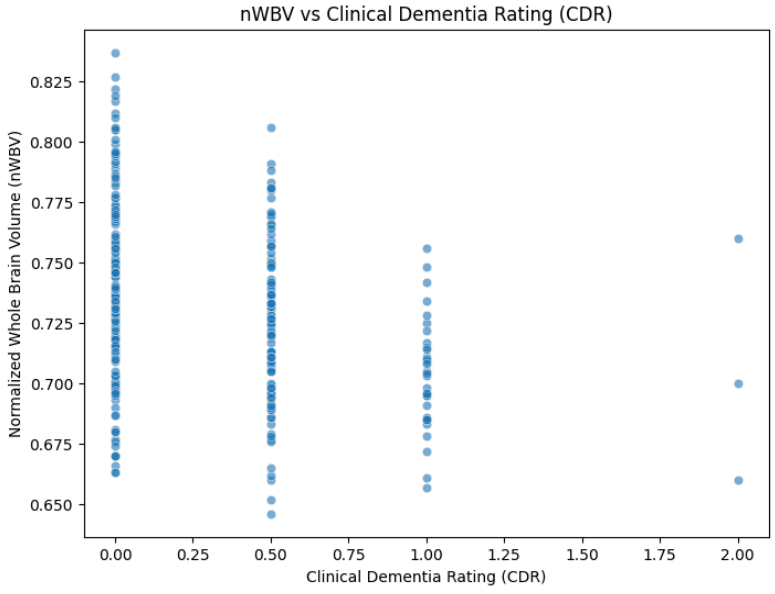

Figure. 2

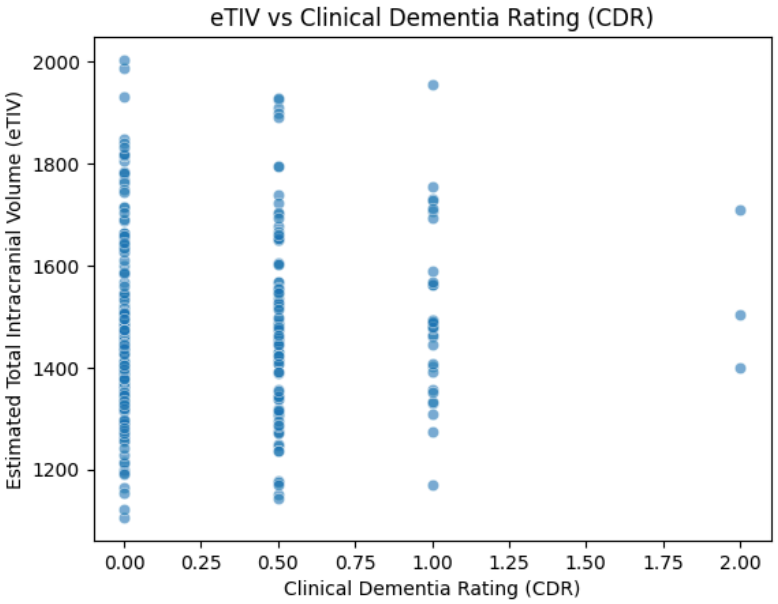

Figure. 3

3. Discussion

The conclusions of the analysis support some of the initial hypotheses while challenging others. The hypothesis that MRI measurements are reliable markers of dementia progression is supported by the statistically significant relationship between nWBV and clinical dementia ratings. In particular, the negative coefficients of nWBV validate the hypothesis that the reduction in brain volume shown by nWBV correlates with the progressive stage of the disease. Contrary to our expectations, the nonsignificant eTIV result implies that it may not be a reliable, independent predictor of the stage of dementia. This finding raises questions about the consistency of MRI measurements, implying that different brain volume metrics represent different disease stages. nWBV was more sensitive to dementia-related changes than eTIV, a result that highlights the complexity of neuroimaging biomarkers.

Furthermore, the power analysis corroborated our expectations about the suitability of our statistical approach, showing that our method could indeed discern significant trends given an adequate sample size. The determination that roughly 45 participants could provide sufficient statistical power underscores the practicality of our research design. And the convergence alert from our mixed-effects model necessitates a cautious approach to data interpretation, adhering to the established model constraints. Such caution invites the reassessment of our findings and could suggest enhancements to our analytical techniques.

In summary, our results support some of the initial assumptions, such as the predictive value of nWBV, but do not support others, such as the validity of eTIV as a predictor. This highlights how important it is to support each hypothesis with empirical data,

which we did in our analysis. To improve our understanding and prognosis of dementia, future studies should continue to explore its complexities using a combination of neuroimaging and clinical assessment.